Minimally Invasive Medial Hip Approach for Treatment of Displaced Pipkin Type 1 Fractures: Surgical technique, quality of reduction and postoperative complications

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Background: *Treatment of femoral head fracture by surgical dislocation of the hip is claimed to provide full exposure of the femoral head but it is technically complex especially for inexperienced surgeon, and heterotopic ossification or trochanteric associated complications may be encountered. We adopted the minimally invasive medial hip approach technique originally proposed by Chiron to expose the displaced Pipkin type 1 fragment and report the surgical technique, quality of fragment reduction and immediate postoperative complication of this approach.*

Patients and Methods: *Ten patients who had stable, congruence hip reduction and Pipkin type 1 fracture with residual fragment displacement more than 3 mm were operatively managed by medial approach. The procedure was performed as originally described by Chiron et al. The quality of fragment reduction was evaluated according to Matta's criteria. Patients were monitored for immediate postoperative complications.*

Results: *Fragment fixation was performed in 9 patients and excision in another. Average operative time and blood loss was 96 minutes and 137 ml respectively. Postoperative fragment reduction quality was classified as anatomical in 4 and imperfect in 5 patients. There was no immediate postoperative complication.*

Conclusion: *Minimally invasive medial hip approach is a safe and relatively simple alternative exposure for surgical treatment of displaced Pipkin type 1 fracture without immediate major complication. The fragment reduction performance is approaching those achieved by the surgical hip dislocation, with less extensile dissection, and neither osteotomy nor re-dislocation of the hip is necessary.*

Keywords: *Pipkin type 1 fracture, minimally invasive medial hip approach, quality of reduction*

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Introduction

Femoral head fractures associated with traumatic hip dislocation are rare injuries usually caused by high energy mechanism[1] but increasing number of road traffic casualties in the present day make them become more common. Being an intra-articular fracture of the largest weight bearing joint resulting from a high energy trauma in young adult patients, the reported outcome of treatments are less favorable, with post-traumatic arthritic change occurs in more than 50% of cases[2]. Because of rarity of this injury, most of the literatures are retrospective review of small case series of patients with different method of treatment and outcome assessment. Choices of management, influenced by patient and fracture considerations, are ranging from simple closed reduction to prosthetic hip replacement[3]. For Pipkin type 1 fracture, stable congruence hip reduction with anatomical fragment reduction may be treated conservatively[1,3-5], whereas surgery is recommended for displaced femoral head fragment[6-8]. Controversies exist, however, as to whether this fragment should be surgically fixed or excised[8-11], and which surgical approach can give the best exposure while minimizing the complications[2,3,12,13]. Recent studies support the surgical dislocation of the hip in operative treatment of femoral head fractures for providing 360˚ view of the femoral head with low complications[3,14-16]. Nevertheless, the complexity of the technique especially for surgeon who had inadequate experience in pelvic and acetabular surgery raises the question of reproducibility of this procedure[17]. In 2014 Chiron et al.[18] reported the novel minimally invasive medial hip approach anterior to all adductor muscles. The procedure was a true intermuscular plane exposure without extensive dissection, osteotomy or having to dislocate the injured hip. In a series of 56 patients with various extra- and intra-articular hip pathology managed by different operative procedure using this approach, there was no neurologic or vascular complication. We adopted this surgical approach to manage displaced Pipkin type 1 fracture in patient with stable and congruence hip reduction, aiming to report the surgical technique, the quality of fragment reduction and immediate postoperative complications.

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Surgical technique

The minimally invasive medial hip approach was done as originally described by Chiron et al.[18] Patient was placed in supine frog-leg position. Incision began at groin fold and followed the path of adductor longus muscle, which could be easily palpated in this position, for 8-10 cm long (Figure 1). The medial accessory saphenous vein might cross the incision and should be ligated. The adductor longus aponeurosis was sharply incised, then blunt dissection was done to create a plane between the aponeurosis laterally and the adductor muscle medially. Care should be taken not to violate the adductor aponeurosis because continuing dissection would lead to femoral vessels. The lesser trochanter facing anteriorly now could be palpated in this abducted-externally rotated position. Hohmann retractors were placed on each side of the femoral neck and kept contact with the bone. Illiopsoas tendon was visualized running in downward and inward direction. Freeing of the illiopsoas tendon was continued using a right-angled clamp and a cord tape was looped under the tendon for retraction. The lateral Hohmann retractor was then re-positioned under the illiopsoas tendon to guard the tendon laterally and expose the inferomedial part of the hip capsule. Medial femoral circumflex arteriovenous vessels running across the inferomedial hip capsule proximally were gently dissected off the capsule and inclined upward. The third Hohmann retractor was placed underneath the circumflex vessels and rest on the anteroinferior wall of the acetabulum to guard the circumflex vessels superiorly and widen the capsular exposure. Capsulotomy was done along the femoral neck in an inverted-T fashion, taking care not to injure the acetabular labrum (Figure 2). The medial and lateral Hohmann retractors were re-positioned intraarticularly on each side of the femoral neck. The Pipkin fragment was now exposed and mobilized, then both the fragment and the femoral head fracture bed were cleaned and debrided. Reduction of the displaced fragment was performed by ball spike pusher while the hip was rotated alternately to allow perfect visualization of the interfragmentary reduction. Temporary Kirschner wire fixation was done and the quality of reduction was verified under image intensifier (Figure 3). Fixation was completed with 2-3 headless screws, depending on the size of the fragment, in antegrade fashion and perpendicular to the fracture plane. Quality of reduction and hardware position was finally checked under image intensifier. Bleeding was controlled, the capsule was repaired and the wound was closed over a suction drainage. Depending on any associated injuries, hip motion was allowed as tolerated immediately after the surgery whenever possible and partial weight bearing ambulation was encouraged after the suction drainage was removed. Neither low dose radiation nor indomethacin for heterotopic ossification prophylaxis was use postoperatively in all patients.

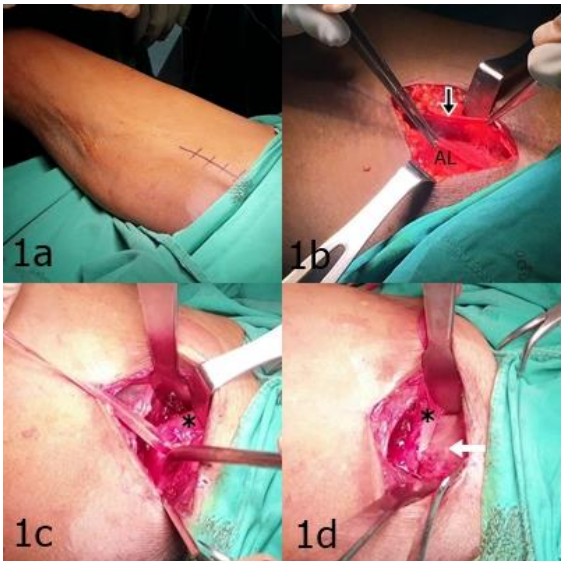

Fig . 1 The minimally invasive medial hip approach of the right hip. *1a*, the patient was placed in supine frog leg position. The incision was made in line of the adductor longus muscle. *1b*, the adductor longus aponeurosis was opened and blunt dissection was done to create a plane between the muscle laterally and the aponeurosis medially. *1c*, the iliopsoas tendon was identified and looped with a cord tape for retraction. *1d*, the lateral Hohmann retractor was re-positioned underneath the iliopsoas tendon to guard the tendon laterally and exposed the inferomedial part of the hip capsule.
AL = adductor longus muscle
black arrow = adductor longus aponeurosis
*iliopsoas tendon
white arrow = hip capsule

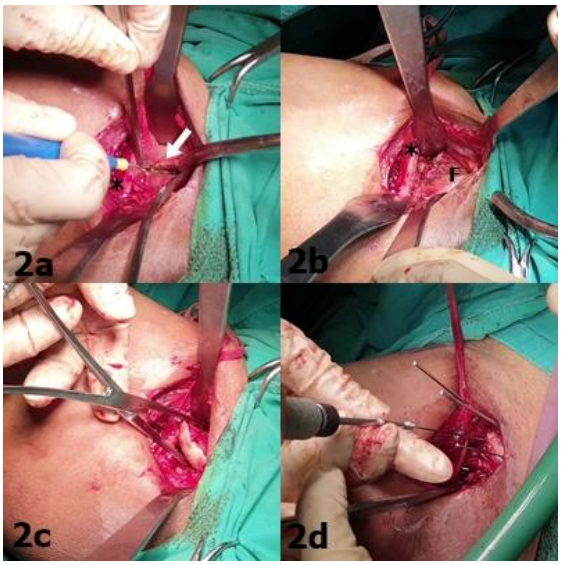

Fig . 2 The minimally invasive hip approach of the right hip. *2a*, the hip capsule was opened with

cautery along the medial femoral neck. *2b*, the medial and lateral Hohmann retractors were re-positioned intraarticularly on each side of the femoral neck. The femoral head fragment was now exposed (which was 180° flipped in this patient and had the cancellous side facing outward). *2c*, the displaced femoral head was manipulated and reduced under direct vision. *2d*, fixation was completed with 2-3 headless screws perpendicular to fracture plane.
* = iliopsoas tendon
white arrow = hip capsule
F = femoral head fragment

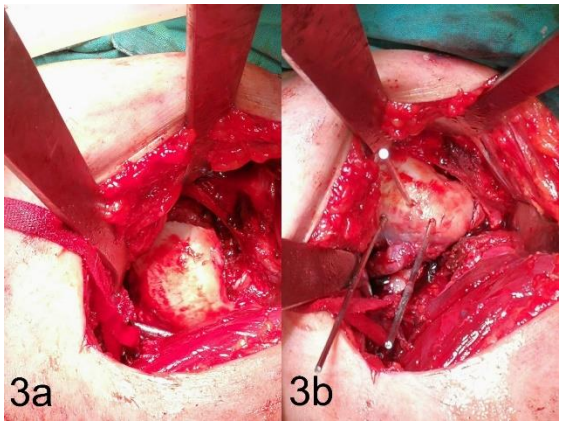

Fig. 3 Reduction of Pipkin fragment. *3a*, visualization of displaced Pipkin type 1 fragment through minimally invasive medial hip approach. The exposure provides adequate and direct access to antero-inferior region of the femoral head. *3b*, temporary K-wire fixation of the Pipkin fragment perpendicular to the fracture plane.

Patients and Methods

From August 2017 to June 2020 the medial hip approach was selectively used to treat displaced femoral head fracture. There were 16 patients with femoral head fracture associated with hip dislocation in Chonburi Hospital during this period. Two patients had stable hip reduction and anatomically reduced femoral head fragment. Two patients had unstable reduction with incarcerated fragments in the hip joint and underwent posterior-based open reduction and removal of fragments. One patient had large posterior acetabular wall fracture leading to unstable hip and fixation of posterior acetabulum was performed via Kocher-Langenbeck approach and had femoral head fragment excised. Another patient who had stable hip reduction but displaced femoral head fragment denied surgical treatment. Ten patients who had stable, congruence hip reduction and Pipkin type 1 fracture with residual displacement of the fragment more than 3 mm demonstrated by CT scan were managed operatively by medial hip approach. All patients gave their informed consent for this unconventional surgical exposure. The operations were performed by a single surgeon (SB). The quality of fragment reduction was evaluated according to Matta's criteria by measuring residual displacement on 2 views of radiograph[19]. Grading of reduction was anatomic if there was 0-1 mm of residual displacement, imperfect for 2-3 mm displacement and poor for more than 3 mm displacement. Medical records were reviewed for operative time, intraoperative blood loss, and immediate postoperative complications such as wound hematoma, excessive hemorrhagic wound drainage, lymphedema and neurologic or vascular injury.

Results

Between August 2017 to June 2020 there were 10 patients with posterior hip dislocation and displaced Pipkin type 1 fracture (Table 1). Nine of them were male. The average age was 33 (16-60) years. Road traffic accident was the mechanism of injury in all patients. Closed reduction of the dislocated hip was performed either under general anesthesia or intravenous sedation. Three patients were polytraumatized and hip reduction was delayed until the hemodynamic status was stabilized. One patient who had undetected hip dislocation was transferred to our hospital 3 days after injury and closed reduction was performed straightaway. The average time from injury to reduction was 14 (3-72) hours. All patients had stable hip after reduction, and computerized tomography of the hip with 3-dimension reconstruction was done afterwards. Two patients had 180° flipped fragment with the cancellous side facing outward (Figure 4). Average operative time was 96 (70-120) minutes and average intraoperative blood loss was 137 (20-400) ml. Nine patients had the fragment reduced and fixed, another had the comminuted fragments excised. There was no immediate postoperative complication. One patient who had moderate degree of head injury and small posterior acetabular wall comminution developed heterotopic ossification of the hip at 8 weeks after the index surgery. The quality of fragment reduction was classified as anatomical in 4, imperfect in 5 patients (Figure 5).

Table 1 Patient characteristic.

Patient number	Age (years)	Sex	Mechanism of injury	Pipkin type	Associated injury	Operative time (min)	Intraoperative blood loss (ml)	Quality of reduction	Complication
1	26	M	motorbike accident	1	none	90	50	anatomic	none
2	60	M	motorbike accident	1	liver injury	120	100	imperfect	none
3	32	M	car accident	1	multiple rib fractures	120	400	imperfect	none
4	25	M	motorbike accident	1	HI*	70	20	fragment excision	none
5	22	F	motorbike accident	1	none	80	150	anatomic	none
6	31	M	car accident	1	HI, pelvic fracture	80	100	imperfect	HO** at 2 months
7	37	M	car accident	1	none	110	100	imperfect	none
8	16	M	motorbike accident	1	femoral shaft fracture	70	50	anatomic	none
9	42	M	motorbike accident	1	none	95	200	imperfect	none
10	42	M	motorbike accident	1	none	120	200	anatomic	none

*Head injury
**Heterotopic ossification

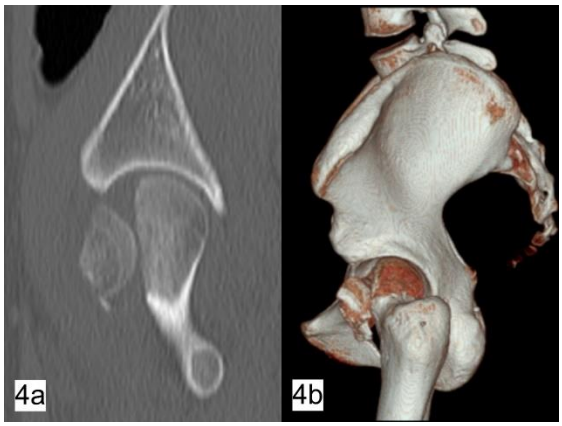

Fig. 4 CT scan of 180° flipped Pipkin fragment with the cancellous side facing outward. *4a*, sagittal reconstruction image. *4b*, 3-D reconstruction image.

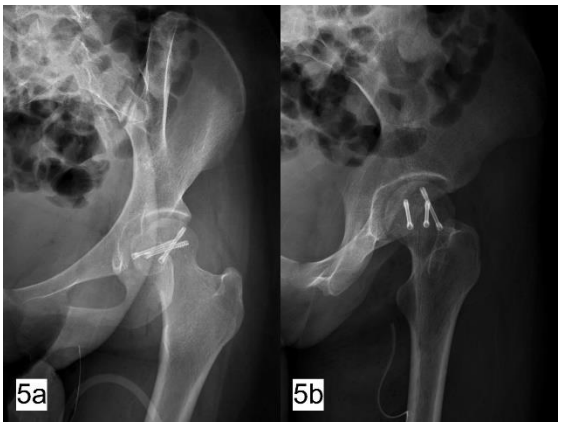

Fig. 5 Evaluation of fragment reduction quality. *5a*, AP internal rotation view. *5b*, AP external rotation view.

Discussion

Femoral head fracture is an uncommon injury. It occurs exclusively with traumatic hip dislocation resulting from high energy injury with reported incidence of 5-15% of hip dislocation[1]. According to Pipkin's classification, surgical treatment is recommended for type 2, 3 and 4; either by operative fixation of the fracture in young adult patient or prosthetic replacement in the elderly[20]. There are many areas of controversy, however, for Pipkin type 1 fracture about treatment strategy (conservative or surgery), appropriate surgical procedure (osteosynthesis or fragment excision) and choice of surgical exposure. Nonsurgical management for Pipkin type 1 fracture may be considered after closed reduction when an anatomic

(<2 mm displacement) reduction of the fragment is achieved, the hip is stable and congruent without any interposed bone fragment[4,9,20], whereas surgery is advocated for nonanatomic femoral head fragment reduction[6,7,20]. Many authors have recommended excision of the fragment in Pipkin type 1 because it is non-weight bearing area of the femoral head caudal to the fovea[1,2,10,11,21,22]. Giannoudis et al.[23] reported in a systematic review of 29 articles that best results were accomplished with fragment excision in Pipkin type 1 fracture, although there was no statistical difference. Biomechanical study showed changes in normal peripheral loading area to a more central position when Pipkin type 1 fragment was excised, and larger fragment excision produced and increase in central acetabular mean and maximum pressure[24]. Park et al.[8] reported a retrospective study of femoral head fractures with at least 5 years follow up and showed excellent or good results were seen in 50% of excision group and 82.6% of the fixation group in patients with Pipkin type 1 fracture. Although there is no consensus in this area of controversy, we believe that this fragment is worth to anatomical reduction and fixation whenever possible, considering it is an intra-articular fracture of a weight bearing joint in active adult patient.

Several operative exposures have been recommended for femoral head fracture treatment. Because each surgical approach is associated with their own risks and benefits, the preferred surgical approach is an ongoing area of debate. The posterior approach may be useful in irreducible posterior hip dislocation or when internal fixation of the posterior wall fragment is necessary in Pipkin type 4 injury[15,20,25]. The Pipkin type 1 fragment is usually located anteromedial[20] and to our experience, although not thoroughly described, fragment fixation is very difficult from the posterior exposure even after the hip is re-dislocated[7,8,26]. Additionally, the posterior approach carries the higher risk of avascular necrosis of the femoral head in comparison to the anterior exposure[15,16,23]. There are many literatures supporting the anterior approach for femoral head fracture treatment[1,6-8,27,28]. Most of the authors report better visualization of the femoral head, shorter operative time and less intraoperative blood loss. However, there are robust evidences of higher risk of heterotopic ossification associated with anterior approach[7,15,20,23] although not all patients required surgical excision[28]. Guo et al.[16] reported in a systematic review of 176 patients that lowest incidence of heterotopic ossification occurred in trochanteric flip than anterior or posterior approach (33.3% versus 42.1% and 36.9% respectively) and highest incidence of osteonecrosis was in the posterior approach (16.9%) compare to trochanteric flip (12.5%) and anterior approach group (11.9%). Recent meta-analysis[13] indicated that posterior approach decreased the risk of heterotopic ossification compared with anterior approach for the treatment of Pipkin type 1 and 2 femoral head fractures, while osteonecrosis of the femoral head and post-traumatic coxarthrosis was not different between these surgical exposures.

Since Ganz et al.[14] described the technique of trochanteric flip osteotomy with surgical dislocation of the hip in 2001, there were torrent of reports of this surgical exposure in various pelvic and acetabular procedure including femoral head fracture management[3,5,15,17,20,29,30]. The advantage of this approach is it provides full exposure of the femoral head while sparing the medial femoral circumflex artery, thus the likelihood of osteonecrosis of the femoral head is decreased. Nevertheless, there are reported complications of sciatic nerve injury, trochanteric pain or bursitis, trochanteric nonunion and heterotopic ossification[14,31,32]. Additionally, the technical complexity of the procedure raises the question of its reproducibility especially in surgeons who do not have a high volume of pelvic and acetabular surgery[17].

The medial approach, which is relatively unpopular in traumatic hip surgery, described by Ludloff and later modified by Ferguson goes between the adductor muscles where branches of the obturator nerve lie in the plane of dissection and carries the risk of nerve injury while providing a limited view of inferior joint area[33]. To our knowledge, there are very few reports on femoral head fracture approached from the medial side[34]. In a systematic review of 177 surgical cases of femoral head fracture, medial approach was used in only 6 patients (3.39%)[23]. Chiron et al.[18] in 2014 proposed a novel minimally invasive medial hip approach in a series of 56 patients with various extra- and intra-articular hip procedure. In his series, there were 3 patients underwent ablation of malunion following fracture-dislocation of femoral head. Cavaignac et al.[35] reported surgical technique of fixation of a femoral head fracture through a medial hip approach and showed good result at 1 year follow up. In our opinion, the advantages of this medial exposure are providing direct access to the antero-inferior region of the femoral head which is the location of Pipkin type 1 fragment, allowing surgeon to fix or excise the fragment without having to re-dislocate the hip or perform extensive bone and soft tissue dissection. The prerequisite for using this medial approach are the fragment must be Pipkin type1 and the dislocated hip must be congruently reduced without intra-articular fragment.

There was no serious postoperative complication in our series, which is comparable to Chiron's study. Despite limited femoral head exposure in medial hip approach, the quality of fragment reduction in our series is anatomic in 4 of 9 patients which is less favorable compare to fragment reduction performance (anatomic in 8 of

13 patients) achieved by the more extensile surgical dislocation approach[17].

Limitation of our study is small number of patients, which corresponds to the rarity of femoral head fractures, and very short follow up period because most of the patients in this series are migrants from other area of the country. Larger number of patients and longer follow up period are required to compare the efficacy of this surgical approach to others in terms of clinical outcomes and complications.

Conclusion

Minimally invasive medial hip approach is a safe and relatively simple alternative exposure for surgical treatment of displaced Pipkin type 1 fracture without immediate major complication. The fragment reduction performance is approaching those achieved by the surgical hip dislocation, with less extensile dissection, and neither osteotomy nor re-dislocation of the hip is necessary.

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Conflict of interest declaration

The author declares no personal or professional conflict of interest regarding any aspect of this study.

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การรักษากระดูกหัวฟีเมอร์แตกชนิด Pipkin type 1 ด้วยวิธีเปิดแผลผ่าตัดด้านในข้อสะโพกแบบบาดเจ็บน้อย (minimally invasive medial hip approach): วิธีการผ่าตัด คุณภาพการจัดกระดูกเข้าที่ และภาวะแทรกซ้อนหลังผ่าตัด

ศันญคุปต์ บุญเพิ่ม, พบ

ที่มา: *การผ่าตัดผู้ป่วยข้อสะโพกหลุดและมีกระดูกหัวฟีเมอร์แตกด้วยวิธี surgical hip dislocation มีวิธีการที่ซับซ้อนและอาจมีภาวะแทรกซ้อนจากการตัดกระดูก greater trochanter ได้ ผู้เขียนได้นำวิธีการเปิดแผลผ่าตัดด้านในข้อสะโพกแบบบาดเจ็บน้อย (minimally invasive medial hip approach) ซึ่งนำเสนอโดย Chiron มาใช้ในการรักษาผู้ป่วยกลุ่มนี้ และรายงานวิธีการผ่าตัด คุณภาพการจัดกระดูกเข้าที่ และภาวะแทรกซ้อนหลังผ่าตัด*

ผู้ป่วยและวิธีการ: *ผู้ป่วยข้อสะโพกหลุดและมีกระดูกหัวฟีเมอร์แตกชนิด Pipkin type 1 จำนวน 10 ราย ที่ชิ้นกระดูกหัวฟีเมอร์แตกยังเคลื่อนมากกว่า 3 มม. ได้รับการรักษาโดยวิธีการเปิดแผลผ่าตัดด้านในข้อสะโพกแบบบาดเจ็บน้อย และรายงานคุณภาพการจัดกระดูกเข้าที่ตามวิธีของ Matta และภาวะแทรกซ้อนหลังผ่าตัด*

ผลการศึกษา: *ผู้ป่วย 9 ราย ได้รับการผ่าตัดใส่สกรูยึดชิ้นกระดูกหัวฟีเมอร์และอีก 1 ราย ได้รับการตัดชิ้นกระดูกออก ระยะเวลาที่ใช้ในการผ่าตัดและการเสียเลือดเท่ากับ 96 นาทีและ 137 มล. ตามลำดับ ผู้ป่วย 4 ราย มีคุณภาพการจัดกระดูกเข้าที่ตามกายวิภาคเดิม และ 5 ราย ที่ชิ้นกระดูกไม่เข้าที่อย่างสมบูรณ์*

สรุป: *วิธีการเปิดแผลผ่าตัดด้านในข้อสะโพกแบบบาดเจ็บน้อยเป็นวิธีทางเลือกที่ปลอดภัยและไม่ซับซ้อนในการรักษาผู้ป่วยข้อสะโพกหลุดและมีกระดูกหัวฟีเมอร์แตกชนิด Pipkin type 1 คุณภาพการจัดกระดูกเข้าที่เกือบเทียบเท่าวิธีการผ่าตัดโดย surgical hip dislocation แต่มีการบาดเจ็บต่อเนื้อเยื่อน้อยและไม่จำเป็นต้องตัดกระดูก greater trochanter หรือเอาหัวกระดูกฟีเมอร์ออกจากเบ้าสะโพกอีก*